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Session 1A

Kentucky Water Resources Research Institute, University of Kentucky

A REGIONALLY-CALIBRATED CRITICAL FLOW FOR STREAM CHANNEL PROTECTION

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The critical flow for stream channel protection ($Q_{critical}$) is defined as the flow, which when exceeded, increases the likelihood for sediment transport of the bed material and/or bank failure. Storms that are managed and released below $Q_{critical}$ are predicted to result in inappreciable channel erosion. In contrast, flows that exceed $Q_{critical}$ are more likely to contribute to channel erosion, widening, and potential impacts to water quality and adjacent infrastructure.

Using data from 23 regional streams, $Q_{critical}$ for Northern Kentucky was estimated to range between approximately 40 and 50% of the 2-year peak flow (Q_2) using the USGS regional equation for rural basins. The range was determined using industry standard mobility equations for the median bed material particle (d_{50}). USGS flow gage data at five (5) of our field sites independently supported this range, indicating that the critical flow for bank failure also appeared to be correlated to approximately **40** to **50% of Q_2**. For every hour of recorded flow that exceeded 40% of Q_2, there was approximately 0.5% channel enlargement in cross-sectional area at the five gage sites.

Given the relationship of watershed hydrologic alteration and overall stream quality, designing stormwater controls to minimize the frequency, magnitude, and duration of $Q_{critical}$ exceedances has the potential to improve downstream channel stability and water quality. When scaling $Q_{critical}$ from stream channels to watersheds draining less than or equal to 100 acres, it corresponds to a maximum discharge rate of **0.36 – 0.45 cfs per acre of development**.

Subsequent analysis shows that water quality BMPs such as bioretention basins can be optimized to achieve the $Q_{critical}$ release rate for storms up to and including the 2-year, 24 hour SCS Type II distribution rainfall event without any additional increase in size relative to existing management policies. That is, stormwater controls can be designed for flood control, channel protection and water quality, at little to no additional cost to local developers.

NOTES

MONITORING WETLAND RESTORATION SUCCESS AT NORTH FORK OF IRISH CREEK

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As part of an EQT Corporation mitigation plan, a forested wetland was restored along the North Fork of Irish Creek, near Blaine, KY. The restoration involved re-grading the area, extensive vegetation planting, and the establishment of a secondary channel. Geomorphic modifications were completed in May of 2010. We completed vegetation planting by August 2011. Quarterly monitoring of vegetative coverage, soil characteristics, groundwater saturation, and water quality characteristics were completed from 2010 through 2011. The hot and dry summer of 2010 was not conducive to the establishment and survival of the trees, shrubs, and herbs planted. Nonetheless, a characteristic wetland flora established. This did not include most of the planted woody species. The wetland appears to be on a successional trajectory towards establishment. The self-design features of the landscape will determine the ultimate biological community.

NOTES

NC2D OPEN CHANNEL FLOW MODEL: DEVELOPMENT AND APPLICATIONS FOR STREAM RESTORATION DESIGN IN KENTUCKY

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NC2D is a new computer model for designing natural river patterns. The model uses an adaptive 3D mesh which is generated and allowed to deform under the forcing of the 2D depth-averaged velocity field perturbations in a sinuous or meandering river with granular bed and erodible banks. An initial solution is created from primary flow characteristics and then natural variation is accomplished using the Mersenne Twister random number generator coupled with the clock randomizer and then Box Meuller transformation to obtain a normally distributed set of pools/meanders along the valley fall line. Parametric curves are fitted to sine-generated functions for each unique pool/meander sequence using a least-squares optimization routine. This same procedure is repeated for each meander until enough are spliced together to cover the valley fall line, with first-order continuity at each splice. A search technique is then used to locate the points of minimum radius of curvature, which are then resized if necessary based on momentum principles and field data collected in natural rivers. This initial solution is then allowed to migrate under steady flows using the 2D meander flow equations coupled with a bank erosion model. The program then optimizes down-valley pool/meander migration by repeating the mesh generation to obtain solutions which obtain minimal or "natural" migration (erosion/deposition) results suitable for design applications.

The model predicts river geometry and 2D velocity patterns very accurately and is useful for design of stream restoration components of water resources engineering projects. Model applications for two projects in Kentucky, one sinuous and one meandering, are presented.

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USING REMOTE SENSING TOOLS TO TARGET STREAM PROTECTION AND WASTEWATER TREATMENT BMPS IN RURAL KENTUCKY

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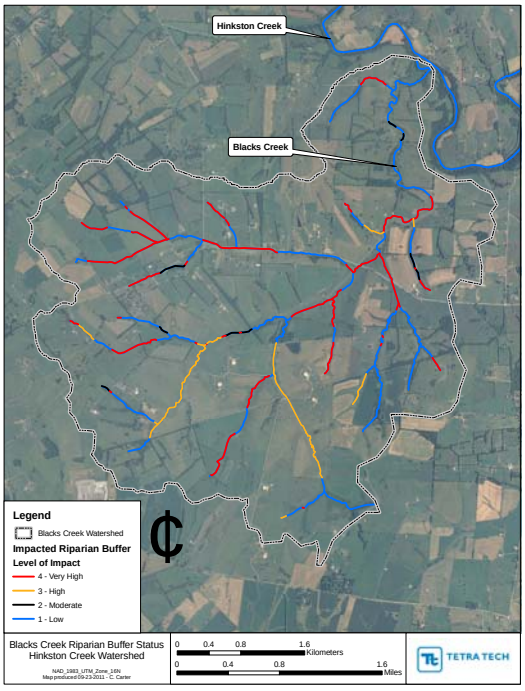
Remote sensing tools – such as GIS mapping, aerial photography, and tailored analysis – can help to identify areas with high risks from septic systems, inadequate riparian vegetation, and livestock concentrations near streams. Results for such analyses can be used to identify pollutant source areas and target management practices. For the Hinkston Creek Watershed CWA 319 Project in east central Kentucky, Tetra Tech produced an onsite wastewater system risk analysis, a riparian buffer assessment, and a focused study of two selected tributaries affected by livestock access to the stream corridor.

Onsite wastewater treatment system potential risk to water quality was assessed via mapping analyses that considered system densities (i.e., number per square mile), system age, and proximity to surface waters. Prioritization was based on level of household density, closeness to streams, and closeness to karst topography (to account for impacts to groundwater). Publicly serviced areas with centralized wastewater treatment were eliminated first; household density was calculated for areas outside of public sewer line boundaries in the areas surrounding the municipalities – within 2 miles of publicly serviced areas in Mount Sterling and within 1 mile of publicly serviced areas for all other municipalities. Household density was not calculated across the entire watershed because septic failure impacts to water quality were assumed to be low in agricultural areas where household density is less than 1 house per acre. Data for calculating household density was obtained from the U.S. Census Bureau's 2000 Census Block data. Closeness to streams was calculated using the high resolution streams data layer created by the United States Geological Survey (USGS) as part of the National Hydrography Dataset (NHD; USGS, 2007). Closeness to karst was calculated using a geologic data layer developed by the Kentucky Geological Survey. Only areas having a household density greater than one household per acre were considered and household density, closeness to streams, and closeness to karst geology received equal weights throughout the prioritization process. Eight census blocks within the Hinkston Creek watershed received prioritization ratings at levels of medium priority (7 blocks) and high priority (1 block). All other census blocks included in the prioritization analysis received ratings of low priority due to low levels of household density (<1 house per acre).

The riparian buffer assessment and deficiency analysis used aerial photography to determine canopy cover presence/absence and buffer zone widths. The stream layer used for the analysis was the high resolution streams data layer created by the United States Geological Survey (USGS) as part of the National Hydrography Dataset (NHD; USGS, 2007). These streams were buffered to create polygons representing riparian buffer areas

for this analysis. A 100-foot buffer was created along each side of the mainstem of Hinkston Creek downstream from the Grassy Lick/Hinkston confluence. A 50-foot buffer was created along each side of Hinkston Creek upstream from the Grassy Lick/Hinkston confluence and along all tributaries within the Hinkston Creek watershed. A Multi-Resolution Land Characteristics Consortium (MRLC) geospatial dataset known as the Landscape Fire and Resource Management (LANDFIRE) map, that provides vegetation and wildland fuel maps, was obtained to determine riparian buffer health status (impacted vs. intact). Using methodology from a recent study (Roy et al., 2005), any vegetated layers with less than 30 percent coverage were lumped together with other impacted riparian habitat LULCs (e.g., developed, open space, pasture/hay, etc.). The percent buffer deficiency within each assessment subwatershed was estimated using GIS. The riparian buffer deficiency, at the assessment subwatershed level, ranges from 45 percent to100 percent throughout the Hinkston Creek watershed. The riparian buffer deficiency for the entire watershed is 75 percent.

A broader, desktop analysis of high-risk stream channel areas was also conducted via mapping work that analyzed riparian vegetation (i.e., canopy cover), cattle access points, and property ownership records. The riparian deficiency data described above was overlaid with imagery from the National Agriculture Imagery Program (NAIP), downloaded from the USDA: NRCS Geospatial Data Gateway website. This was used to assess the intensity of impact on riparian areas within the Blacks and Boone Creek watersheds. Imagery used covered all of Bourbon County and was acquired by NAIP during the agricultural growing season in 2010. Reaches within each watershed were visually scanned against the NAIP imagery to assess the land cover context for riparian buffers. Impacted riparian areas were divided into four levels of impact based on stress conditions observable from the aerial imagery, such as proximity of intense tilling and/or grazing to the stream edge, cattle access points, and lack of tree or shrub cover in the riparian buffer. Best professional judgment was used to assign a level of impact to each reach segment according to the definitions of levels of impact. Cattle access points were visible along some reach segments from the aerial imagery. Evidence of bare stream or pond banks that were within observable pasture boundaries were considered cattle access points. These points were highlighted for the targeted streams (see figure). Parcel boundaries were obtained from the Bourbon Counter Property Valuation Administrator to identify landowners who might be interested in stream protection BMPs. A table identifying high risk areas and parcel owners was developed to support BMP implementation efforts.



IMPROVING WATER QUALITY THROUGH STREAM RESTORATION AT TOWN BRANCH: AN URBAN WATERSHED CASE STUDY

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Improving stream water quality and restoring physical stream stability and habitat have both been shown to increase aquatic life and stream health. However, physically degraded, urban streams with poor water quality from non-point source pollution have often been excluded from receiving regulatory agency and/or funding support due to concerns that restoring the physical habitat could be in vain if the water quality is too poor to support robust aquatic life.

Town Branch (a tributary to Strodes Creek in Clark County), is a typical stream for the Bluegrass Region in Central Kentucky. It has many of the issues and ailments of urban waterways in this area including anthropogenic alterations such as channel straightening and dredging, draining of adjacent wetlands, sewer/utility lines, non-point source pollution from urban runoff, and limited riparian forest buffer.

The Kentucky Transportation Cabinet (KYTC) partnered with the Strodes Creek Conservancy to restore approximately 7000 feet of degraded Town Branch channel on City of Winchester property as an advance stream mitigation site. Due to concerns that the runoff from the mostly urban watershed would cause poor water quality in the stream, the U.S. Army Corps of Engineers and Kentucky Division of Water set high standards for biological success for the project.

To ensure the project met the biological success criteria, KYTC incorporated several measures into the stream restoration project to improve stream water quality, in addition to restoring the physical stability and habitat of the stream. This presentation highlights innovative features and techniques used to improve stream water quality as part of stream restoration in an urban watershed.

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